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(54) Constant current electric motor drive for fan

(57) A motor (M) for driving air through a replaceable filter to the face of a wearer of a protective helmet is supplied with power from a rechargeable battery pack (P) through a current regulator (11) which is controlled to tend to maintain the motor current constant in spite of variations in the battery voltage or the degree of clogging of the filter. The voltage across the motor, measured by resistors 13,14,15, can be used as a measure of the degree of clogging of the filter to actuate an audible or visible alarm B if the filter becomes too clogged. The voltage across the regulator 11, measured by resistors 16, 17, 18 can be used as a measure of the voltage of the battery to give a visible or audible warning if the battery charge gets too low. The two different warnings can be distinguishable from one another.

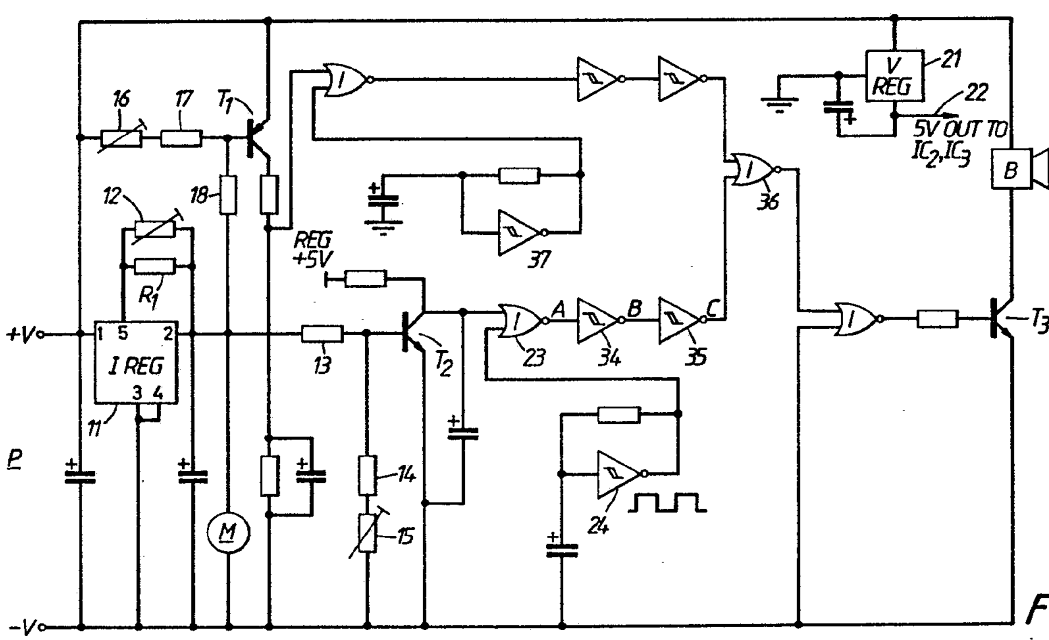

FIG.1.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.
The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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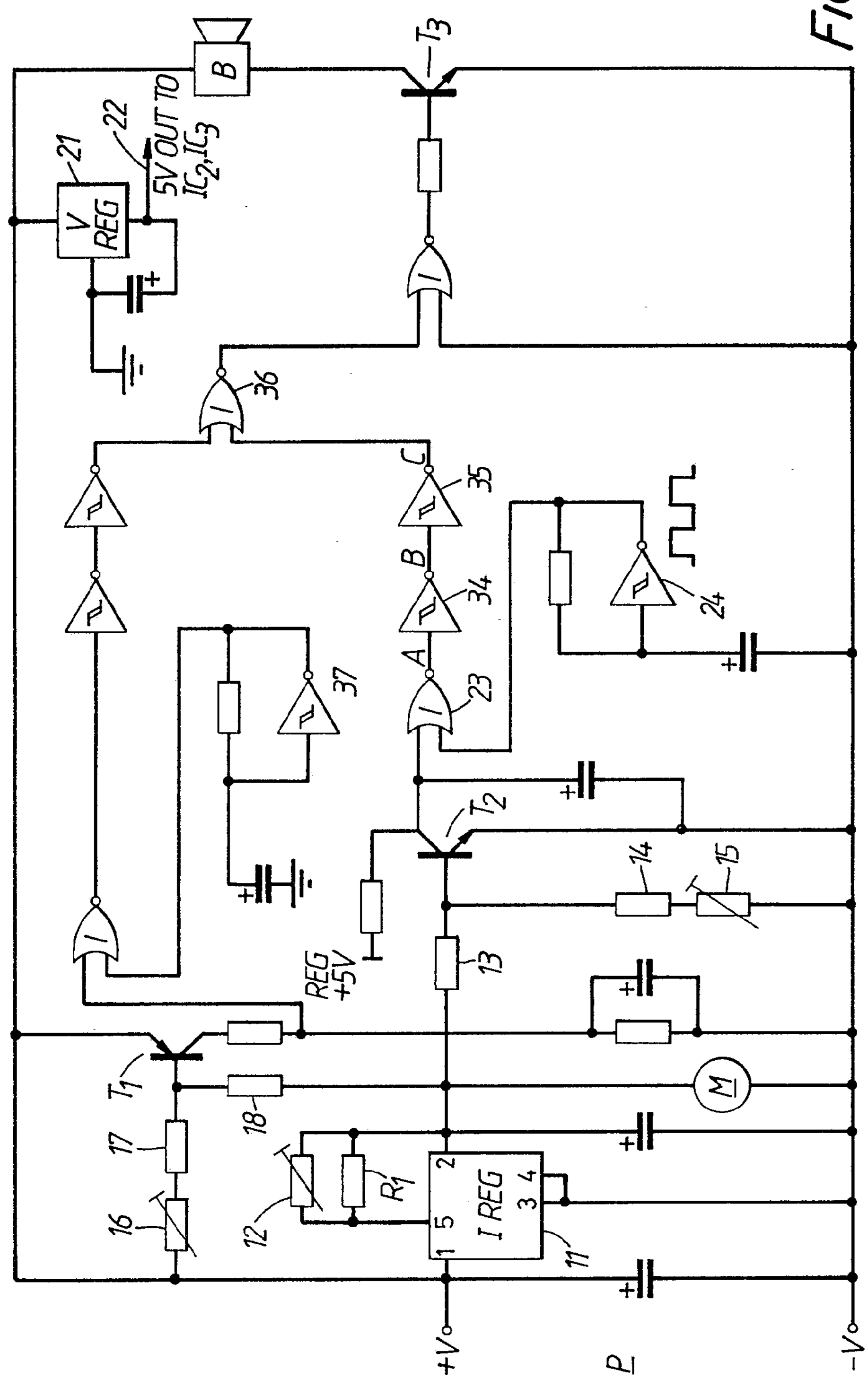

FIG.1.

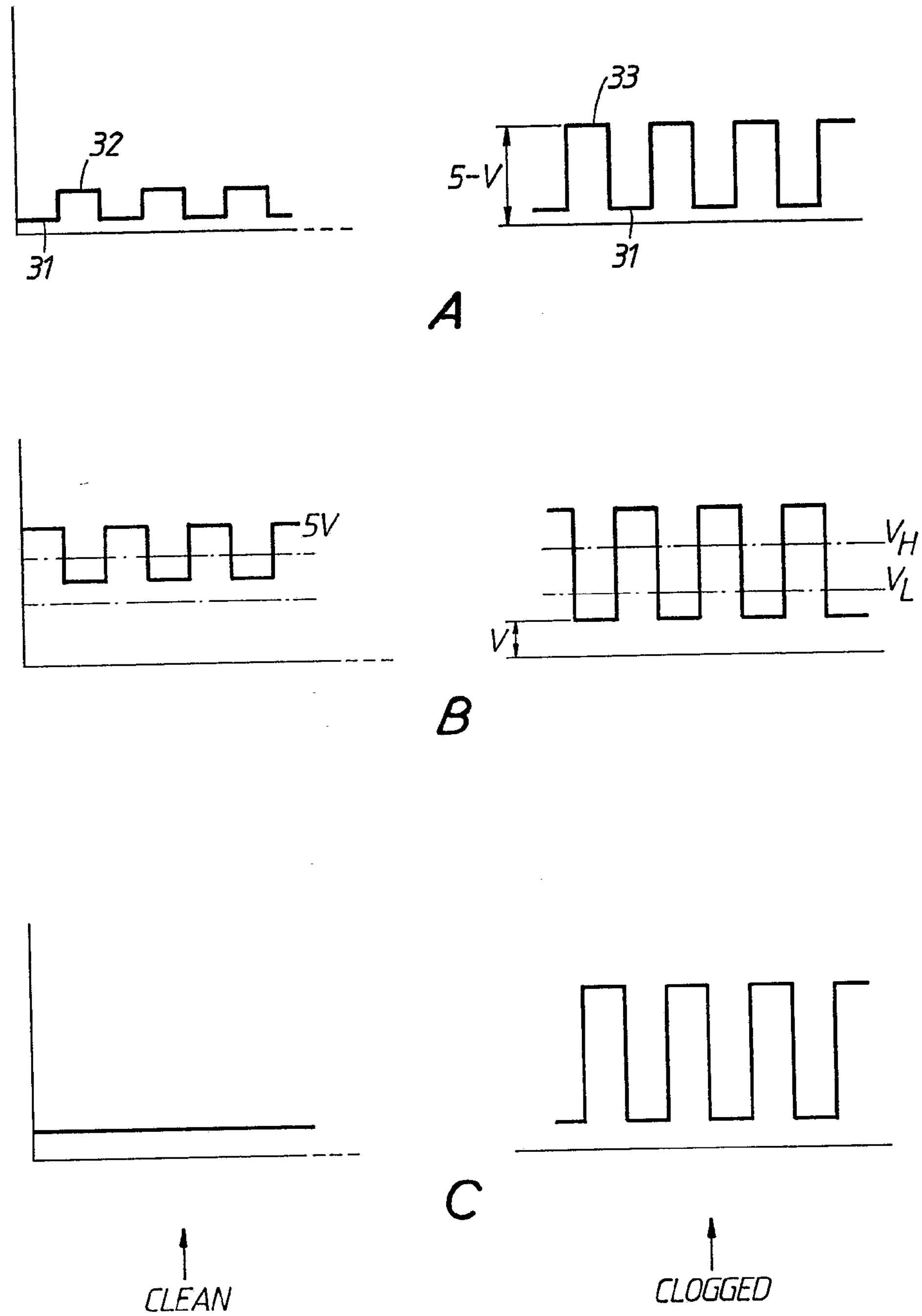

FIG. 2.

SPECIFICATION

Electric motor drive

This invention relates to a drive for an electric motor, for example, a battery driven d.c. motor in a protective helmet for driving a fan for drawing air through a filter mounted in the helmet for the wearer to breathe.

British patent specifications nos. 1574311, 2061696 and 2063074 describe various helmets of that kind. The inventions, the subjects of those patents are not concerned with the supply to the electric motor, but in general, the motor is a d.c. motor being driven from a rechargeable battery pack which may be separately mounted on the belt of the wearer.

Such a simple arrangement is not always very satisfactory, because the performance can vary substantially in dependence on whether the filter is clean or clogged and over the period of several hours during which the battery pack is discharging. In order to achieve a desired minimum rate of flow of air at the end of a shift, it may be necessary to deliver an excessive amount of air at the beginning which tends to clog the filters early and wastes power from the pack.

According to one aspect of the present invention, in a method of driving an electric motor for driving a fan, the motor current is maintained generally constant.

It has been appreciated that if the filter begins to become clogged, the fan drives less air and so is not so heavily loaded and its current drops and/or its speed tends to increase. However, if the voltage can be automatically increased to tend to maintain the current constant, the motor can be additionally loaded sufficient to draw more air through the filter and provide the necessary flow rate.

There is the additional advantage that the voltage supplied to the motor is a measure of the degree of clogging of the filter and can be used to give a warning if the filter becomes so clogged that a desired flow rate cannot be achieved. That can be achieved without providing a special flow meter.

According to another aspect of the invention, an electric circuit for supplying a fan-driving motor from a battery includes a current regulator arranged to tend to maintain the motor current constant in spite of variations in battery voltage or available air supply.

The regulator can be programmed to increase the voltage across the motor in response to a drop of current drawn from the regulator.

The circuit can also be arranged to given an alarm in response to an excessive voltage supplied across the motor and/or an alarm in response to a low volt drop across the regulator which will be a symptom that the battery pack is near the end of its discharge cycle.

Although the invention has been described as particularly applied to the supply of current from a recharageable battery pack to a d.c. motor for driving a filter in a protective helmet, it will be clear that the invention is not limited to that particular use, but has other applications.

The circuit can be embodied in the protective helmet which will also mount the motor driven fan, possibly as a single unit, and a replaceable filter through which air is drawn for direction over the face of the user.

The helmet can be of rigid construction to give protection against blows while also providing the clean air supply to enable the user to work in contaminated areas.

The invention may be carried into practice in various ways, and one embodiment will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a diagram of a circuit for supplying from a battery a fan-driving motor in a protective helmet; and

Figure 2 is a set of characteristics showing the voltages respectively at points A, B and C in the circuit of Figure 1, the characteristics at the left-hand side of Figure 2 being when the filter through which the air is drawn, is clean, and the characteristics to the right of Figure 2 showing conditions when the filter is becoming clogged.

The motor M is a 3.5 V d.c. motor with a permanent magnet field and is supplied from a battery pack P through a current regulator 11 in the form of an integrated circuit in combination with an adjustable resistor 12 for setting the constant current to be drawn from the regulator. The regulator operates by detecting a decrease in the drawn current and increasing the voltage output in the sense to restore the current to the set value.

The power supply P is a nominal 6 v nickel cadmium secondary battery pack which produces about 7.2 V when fully charged reducing to about 6 v after some hours of discharge.

The voltage across the motor M is monitored by a potential divider consisting of resistors 13, 14 and 15, of which the resistor 15 is adjustable. A common point of the resistors 13 and 14 is supplied as a base bias voltage to a monitoring transistor T_2.

In a similar way, the voltage across the current regulator 11 is monitored by a potential divider 16, 17 and 18 of which the resistor 16 is adjustable while the junction between the resistors 17 and 18 is supplied as a base bias voltage to a monitoring transistor T_1.

A second integrated circuit 21 is connected as a voltage regulator for providing a 5 V d.c. regulated output at 22 for use as the power supply to the transistor T_2 and the logic circuits. The voltage regulator 21 obtains its input supply directly from the battery pack P.

The motor is mounted in a protective helmet and drives a fan which draws ambient air

through a filter for delivery to the face of the wearer.

Initially, with the battery pack P fully charged and the filter clean, the resistor 12 is set to produce a current in the motor M for delivering 120 litres of air per minute.

As the battery pack begins to discharge, any tendency of the motor current to fall correspondingly will be compensated for by the current regulator 11 so that the nominal current and air flow rate are maintained.

As the filter begins to clog, the air supply begins to fall so that the motor becomes less loaded and the current tends to drop so that, again, the regulator 11 operates to increase the voltage across the motor to tend to restore the current to the nominal value. In that way the power drawn by the motor increases so that the nominal 120 litres can be maintained, even though the filter is beginning to be clogged.

It will be apparent that the voltage across the motor will be a measure of the degree of clogging of the filter and that is reflected at the voltage on the base of the transistor T_2. The more the filter is clogged, the greater will be the voltage at the base and so smaller at the collector of the transistor T_2.

That voltage is used to monitor the degree of filter clogging by supplying the collector voltage of the transistor T_2 to one input of a NOR gate 23, the other input to which is supplied from a Schmitt trigger 24 producing a square wave output.

The output A from the NOR gate 23 is as shown in the top characteristics in Figure 2 being low as indicated at 31 during the marks of the square wave from the Schmitt trigger 24 and being at a higher value during the spaces corresponding to the difference between the 5 V regulated supply to the transistor T_2 and the collector voltage. That higher value increases as the filter begins to clog from a low value 32 shown at the left of Figure 2A to a higher value 33 shown at the right of Figure 2A. The height of the square pulses 32 and 33 will be (5-V) where V represents the collector voltage. As the voltage across the motor M and the voltage on the base of the transistor T_2 increase, the transistor T_2 draws more current so that the drop across the collector resistor increases and the voltage at the collector decreases while the value 5-V increases. The voltage at A is fed through an inverter 34 which delivers at B the characteristics shown in Figure 2B which is at 5 V during the marks of the square wave from the Schmitt trigger 24 and is at V during the spaces.

Thus, every time there is a transition from the Schmitt trigger from a mark to a space, the voltage at B will reduce from 5 V to V.

The signal at B is fed to a threshold device 35 which has increasing and decreasing trigger voltage levels as indicated at VH and VL in Figure 2B. At the beginning of every mark of the characteristic 2B the voltage rises above the threshold level VH to 5 V causing a low ouput.

The low threshold VL for decreasing voltage will be crossed when the filter is clogged as shown at the right in Figure 2B, but not when the filter is clean as shown at the left in Figure 2B. Once that trigger level is crossed, an output is given at C as indicated in Figure 2C and that is supplied through a NOR gate 36 to a transistor T_3 for controlling the supply of current through an alarm buzzer B.

The other input to the NOR gate 36 is derived from an alarm circuit similar to the circuit including the components 23, 24, 34 and 35, but derived from the collector of the transistor T_1 and so responding to the voltage differential across the regulator 11. A Schmitt trigger 37 may have a different pulse rate from that of the trigger 24. If either the filter becomes too clogged or the battery is near the end of its discharge cycle, and the voltage across the regulator is too low, an alarm will be given at the buzzer B.

The advantage of providing the constant current regulator for supplying the motor M is that the air flow is independent of the battery voltage, at least during the greater part of the discharge cycle, and that the motor power consumption is increased as the filter begins to be clogged in order to maintain the desired rate of air flow. There is no need to provide excess air flow at starting when the battery is charged and the filter is clean, so that the life of the battery pack charge is as long as possible.

Also, the circuit gives very convenient means for providing a warning signal if either the filter gets too clogged or the battery voltage gets too low.

It is to be noted that the alarm may be set to trigger when the air flow output from the fan falls below a predetermined level, because it is the air flow rate that is indicative of a clogged filter or a low battery.

The circuit can distinguish between a) a clogged filter and b) a combination of a low battery with a clogged filter or a low battery by arranging for the Schmitt triggers 24 and 37 to have different frequencies—which can be distinguished aurally at the buzzer B, or by including visible indicators responsive to inputs to the NOR gate 36.

Although the invention is described as applied to a powered protective helmet, it has other applications. For example, it can be used to supply filtered air via a hose to a pressure ventilated blouse, or to a ful face piece or a half-mask, or to some other device for using filtered gas under pressure.

CLAIMS

1. A method of driving an electric motor for driving a fan, in which the motor current is

maintained generally constant.

2. A method as claimed in Claim 1, in which the fan is arranged for driving fluid through a filter, which can become progressively clogged.

3. A method as claimed in Claim 2, in which a signal derived from the voltage across the motor is used as an indication of the degree of clogging of the filter.

4. A method of driving an electric motor for driving a fan performed substantially as herein specifically described with reference to the accompanying drawings.

5. An electric circuit for supplying a fandriving motor from a battery, including a current regulator arranged to tend to maintain the motor current constant.

6. A circuit as claimed in Claim 5, in which the regulator is controlled to increase the voltage across the motor in response to a drop of current drawn from a regulator.

7. A circuit as claimed in Claim 5 or Claim 6 including an alarm arranged to be triggered in response to an excessive voltage supplied across the motor.

8. A circuit as claimed in any of Claims 5, 6 and 7, including an alarm arranged to be triggered in response to a low volt drop across the current regulator.

9. An electric circuit for supplying a fan-driving motor from a battery arranged substantially as herein specifically described with reference to the accompanying drawings.

10. A protective helmet incorporating a motor-driven fan for supplying air to the face of the wearer through a replaceable filter, and incorporating an electric circuit for supplying the motor as claimed in any of Claims 5 to 9.

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